Introduction to GEOTRACES Q & A Transcription

Q: For many of my students, it's hard to get them excited about chemistry. How do you get inspired to study it, and any ideas on how to make it more interesting?

A. I like to take a crack at that and then I'll have Ben go. What I like about chemistry is that it's the integrator. Now, I'll tell you why I like it and then I can maybe start thinking about how to get the students interested. What chemistry does is it's almost like forensics. You leave a record of biological and physical processes, and so as an oceanographer we have to think about all of these different processes. They all leave some sort of imprint. Chemistry is the best imprint for these processes to leave. So as I am trying to understand how the ocean works. I find that the chemistry of the ocean is the best way or at least my favorite way to understand all of these processes are going in and out or they're happening in the ocean, [both?] the biological ones, the geological ones, and the physical ones. So that's why I like it. How I got into it, I don't know. I guess I was studying environmental engineering, and had a little bit of everything, a little bit of math, a little bit of physics, a little bit of chemistry, a little bit of biology. The chemistry part I guess I'm not a chemist by training, but I guess just back to the evidence that is left in the chemistry I guess I find it the most compelling in terms of trying to understand the ocean.

A. Yeah. My answer is actually very similar to Phoebes. I would say I got interested in chemistry, a particular inorganic chemistry in metals, through biology. So I was very interested in the oceans and their productivity. That lead me—as I talked about tonight—to look at the nutrients that limit them, and that ends up being metals in some cases, as we talked about. Essentially organisms are big balls of elements and each of them has a unique role. I've gotten interested in the elements because we need to understand them to understand the biology and the ecology. And I think my other answer is similar to Phoebes, and that is chemistry is the central science, to use a textbook phrase I learned in college. I think it really is the science that integrates across these fields. It connects to the biology, then it connects to the geology, and then it connects to earth science. And then it connects to biochemistry, and it connects to muscular biology. All of the things occur because they are made up of elements. It's because it is quite amenable to interdisciplinary interests.

A. Yeah. I agree.

Q. What are some of the research questions that are driving the work being done by GEOTRACES?

A. Right. I think Phoebe talked in broad brush for example: What are the sources and sinks? Then for each of these cruises they are conducted by—mostly at least in the U.S. cruises—in many cases 20 or 30 individual principal investigator groups, each of which writes a proposal to the National Science Foundation to support their participation. Each of those has their own hypotheses and scientific questions that they want to address. For example, my role in the North Atlantic cruise—that was one of the lines that Phoebe showed—was to examine how the contents of metal in phytoplankton change across the basins. So one of the things that we have learned is that—and I've talked about atmospheric emissions, and I've talked about human emissions—copper can come into the Atlantic Ocean from

industrial emissions from Europe. One thing that we've seen is that there's a lot more copper in the phytoplankton near Europe than there is in the middle of the ocean, so that's something that tells us something about how the metals are cycled. So I had some specific questions about how the plankton respond to gradients in these sources and sinks. That's an example. I don't know if Phoebe wants to add one.

A. Yeah. I would just add that this is a good schematic to illustrate that. As oceanographers we know that there is these major processes that happen in the ocean, for example, equatorial upwelling in the Central Pacific. Each of us who participate in the GEOTRACES program is usually an expert on one particular aspect, maybe one trace metal, or one aspect of the trace metal cycling. So we each come to, let's say equatorial upwelling, with our own lens. But we're all interested in trying to understand what equatorial upwelling does to 'xyz.' For example, for equatorial upwelling, that usually causes a lot of productivity, because it brings in nutrients from the deep, and it may bring in trace metals from the deep, and so we would be interested in understanding how that affects productivity. Ultimately, someone else, maybe some fisheries person would be interested in understanding how that might affect seafood down the line. As chemical oceanographers we're interested really in what causes the chemicals to be distributed the way they are. We are interested in the processes that do this. Every single investigator has a unique lens in which to do this.

Q. You mentioned that some of the materials you measure are toxic. Are they dangerous for you to work with?

A. Right. Usually most elements occur at very low concentrations; that's what we've been stressing through the GEOTRACES program. So even something like mercury in seawater occurs in very low concentrations, what we call picomoles per liter. It's only toxic because, in the case of mercury, it's accumulated within organisms in the ocean. Even a swordfish, it's not toxic or not harmful to work with that. If you ate a lot of swordfish over a long period of time you are going to have some problems. But in most cases they are not at high enough levels that are toxic for those of us working in the ocean.

Q. Measuring iron is very difficult because it is everywhere. How do you find true blank so that you can measure iron absolutely?

A. You want to do that one Phoebe, or do you want me to do it?

A. I'll take a crack at it, and then you can amend. That's a good question. We use very clean chemical reagents in order to measure things. So for example we'll dissolve things in acid that had been quartz distilled, or doubly distilled, so that we can basically distill out the impurities and only have these very pure [assays?]. Our chemical reagents are very clean. All the dust bowls that we use to measure these things have been acid bleached in order to wash away any contaminants. So we use our blanks then as our baseline. We're not going to have no iron; there will be iron in it. Then everything we measure will

be on top of that baseline. We want to get our baseline as low as possible so that we can measure small amounts, but we always will then subtract the amount of iron that's in our blank.

A. Yeah, an example of that iron, Phoebe showed that picture of the big 500 liter tank that was collected. One of the things that they done on this cruise is that they collected this tank of seawater from an area that had very low iron concentrations in the surface waters. That has then been distributed to hundreds if not thousands of different people, [or leastwise?] the samples have been distributed, so that everyone has the same water at very low iron concentrations, and that's important for everyone to assess their blanks, because again at those low concentrations that can be a big part of the correction. By having everybody around the world able to analyze the same sample of water, we can be really confident that each person is estimating their blanks accurately. It's a very good question.

A. That's right. In fact everyone that reports data has to report their value for that standard that came out of that tank. That way we can make sure people's data are actually good.

Q. A couple people have asked about the intermediate data product. What other elements besides that iron movie that you showed that people can take a look at there?

A. Yeah. Let's click on the electronic atlas. If you click on the 3d scenes there, what you'll see now is that you can select a data group. Let's select trace metals, but there's also other stuff. Then if you go to *Select a Tracer*, then you'll see all of these elements which have the movie, so aluminum, barium, cadmium, copper, iron, manganese, nickel, lead, zinc. That's just for the trace elements. If you go back to the Trace Elements part you can select different groups, radioactive isotopes for example. Then there'll be anything that is a radionuclide will be listed there. Let's see, I think there were 70 different parameters, including nutrients, including basic hydrographic parameters that other programs including GEOTRACES measures, but that are essential for us to interpret our data. I would encourage anyone that is interested to go to this eGEOTRACES site, and you can play around with it. I just showed you the Atlantic one, and I chose iron, but you can choose the Arctic, you can choose the Indian. Then stay tuned for a few more years we'll have data from the Pacific, and more data from the Indian and the Arctic to add to this.

Q. How will GEOTRACES be involved in assessing the next step? In other words how will they get involved with people using their data about investigating how changing climate is going to affect all of these elements? You mentioned climate modelers may be using it.

A. Yeah, so I can take the first crack and then Ben can maybe add something. For example a lot of earth system models including our climate models basically have iron in them. That's because iron is such an important control on photosynthesis in the ocean, that in order to predict photosynthesis in the ocean right, you have to add iron. So with this big database now they can represent iron in their models much better. There are other ways in which this can be understood. Some of the radioisotopes for example,

protactinium and thorium, have been used to understand past climates. That ratio has been used to try to infer past circulation in the ocean, and that is thought to maybe affected the climate in the northern hemisphere especially.

A. Yeah, and I might add that GEOTRACES is really actively and proactively engaging with the modelling community. I think that it's often been the case with individual investigators that they publish their data and sort of assume that it will be used by that community. And in the case of GEOTRACES even as these cruises are going on, there will be workshops, international workshops held where we are bringing people in who work on climate, who work on modeling, who work on past reconstructions, showing them the data and making sure we understand what they need and their questions and how to get that process started. That's a real strength for the program too.

Carla. I think that's all the time we're going to have for questions tonight. I want to thank again Dr. Benjamin Twining and Phoebe Lam for their presentations, and also to the audience for asking such awesome questions. As usual, you never disappoint me with the awesomeness of your questions.